

TITLE OF THE INVENTION  
IMAGE PROCESSING APPARATUS AND METHOD

FIELD OF THE INVENTION

5           The present invention relates to an image  
processing apparatus and method and, more particularly,  
to an image processing apparatus and method which  
accurately estimate the display color of an acquired  
object, regardless of the conditions of observation  
10   illuminating light, by using the spectral distribution  
data of the object.

BACKGROUND OF THE INVENTION

          The method most often used in apparatuses which  
15   acquire spectral distribution data is to divide into  
bands a wavelength region (to be referred to as a  
"total wavelength region" hereinafter) to be measured  
such as a visible light region, acquire the spectral  
distribution information of each band, and acquire the  
20   spectral distribution information of the total  
wavelength region from the results.

          Fig. 1 is a block diagram showing the arrangement  
of a multi-spectrum camera 207 for acquiring spectral  
distribution data.

25           A plurality of filters having spectral  
characteristics different in wavelength are arranged  
along the periphery of a disk-like rotary filter 202 in

order of band wavelength. Reflected light from an object to be sensed passes through an optical system 201 and through one filter on the rotary filter 202, and is decomposed into light indicative of band

5 information. By rotating the rotary filter 202 placed before a CCD sensor 204 by a driving motor 203, filters facing this CCD sensor 204 are switched, and input light is decomposed into light indicating each band information.

10 The intensity of the light indicating band information is converted into a digital signal value by the CCD sensor 204 and an A/D converter 205, and stored as data in units of pixels into a data storage unit 206.

15 Generally, the smaller the number of filters of the rotary filter 202, the shorter the processing time required for sampling and the higher the speed of image sensing. Therefore, the number of filters is minimized.

As indicated by the solid lines in Fig. 2, the spectral distribution data acquired by the  
20 multi-spectrum camera 207 is the information of each band decomposed by the corresponding filter. Hence, this data cannot be directly used as the spectral distribution data of the total wavelength region. Therefore, it is necessary to acquire the spectral  
25 distribution data of the total wavelength region by interpolating the information of each band. Note that the spectral distribution data of the total wavelength

region will be called "multi spectral distribution data", with respect to band information acquired by the multi-spectrum camera 207.

In this interpolation, as shown in Fig. 2, an  
5 intensity value corresponding to the intermediate wavelength of each band is defined as band information (indicated by symbol ● in Fig. 2). These pieces of band information are connected by a curve (indicated by the broken line in Fig. 2) to obtain multi spectral  
10 distribution data as the spectrum interpolation result. Fig. 2 shows the spectral characteristic acquired by the multi-spectrum camera 207 having six filters. In this case, multi spectral distribution data must be estimated by using band information having six fixed  
15 filter characteristics.

Methods other than the above interpolation process are available by which the spectral distribution data of the total wavelength region is obtained by using band information. One method will be  
20 explained below.

A function for obtaining an output value at a wavelength  $\lambda$  of the spectral distribution data information of each decomposed band is defined as  $R_n(\lambda)$  where  $n = 1, 2, \dots$   $n$  corresponds to the  
25 information of each decomposed band. Spectral distribution data  $R(\lambda)$  of the total wavelength region is calculated as a linear sum at different wavelengths

of  $\text{Ln}(\lambda)$  given by

$$R(\lambda) = \sum_{\lambda} \{a_1 \cdot L_1(\lambda) + a_2 \cdot L_2(\lambda) + \dots + a_n \cdot \text{Ln}(\lambda)\} \quad \dots (1)$$

where  $a_1, a_2, \dots, a_n$  are arbitrary coefficients which

5 can be different from one wavelength  $\lambda$  to another

In addition to the above method, methods represented by the KL expanding method are known by which the spectral distribution data of the total wavelength region is obtained from band information.

10 Accordingly, an optimum method is properly used in accordance with, e.g., the characteristics of band information.

A technique which realizes perfect color matching between environments differing in environmental  
15 illuminating light, i.e., environments having illuminating lights different in spectral distribution is disclosed in, e.g., Japanese Patent Laid-Open No. 9-172649. Since this technique uses spectral distribution data, it is necessary to acquire the multi  
20 spectral distribution data of illuminating light by using the multi-spectrum camera 207 as shown in Fig. 1, i.e., to estimate the spectral distribution of illuminating light.

Estimating the spectral distribution requires not  
25 only the image sensing time of the multi-spectrum camera 207 but also, in order to process all band information acquired, large amounts of memories for

storing all band information in units of pixels and working buffer memories. In addition, a processing time for processing all the band information is necessary.

5           Furthermore, to avoid errors produced by the interpolation process described above, it is necessary to use complicated interpolation and increase the number of band information. This increases the load (time) of image sensing and processing.

10

#### SUMMARY OF THE INVENTION

The present invention has been made to individually or collectively solve the above problems, and has as its object to reduce the load (time) of  
15 image sensing and processing when estimating a spectral distribution.

To achieve the above object, one preferred aspect of the present invention discloses an image processing apparatus comprising: a first acquisition section,  
20 arranged to acquire color data of an object; a second acquisition section, arranged to acquire a plurality of spectral distribution data on the basis of the configuration of spectral distribution data defined in accordance with the acquired color data; and a  
25 generator, arranged to generate image data constructed by the acquired color data and the plurality of spectral distribution data.

Another preferred aspect of the present invention discloses an image processing apparatus comprising: an input section, arranged to input image data constructed by color data and a plurality of spectral distribution data; and an estimator, arranged to estimate spectral distribution data of a total wavelength region on the basis of the configuration of the spectral distribution data defined in accordance with the color data.

Still another preferred aspect of the present invention discloses an image processing apparatus comprising: a first acquisition section, arranged to acquire color data of an object; a second acquisition section, arranged to acquire a plurality of spectral distribution data on the basis of the configuration of spectral distribution data defined in accordance with the acquired color data; an estimator, arranged to estimate spectral distribution data of a total wavelength region on the basis of the configuration of the spectral distribution data; and a generator, arranged to generate the spectral distribution data of the total wavelength region from the acquired color data and the plurality of spectral distribution data, on the basis of the estimated spectral distribution data of the total wavelength region.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying

drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the arrangement of a multi-spectrum camera for acquiring spectral distribution data;

10 Fig. 2 is a graph for explaining the spectral distribution data acquired by the multi-spectrum camera;

Fig. 3 is a block diagram showing the arrangements of an image sensing device for sensing an object and an image processing apparatus;

15 Fig. 4 is a graph showing the acquisition result of eight pieces of band information when a bluish color is sensed by the multi-spectrum camera;

Fig. 5 is a graph showing a method of estimating multi spectral distribution data in an embodiment;

20 Fig. 6 is a graph for explaining band information necessary to estimate multi spectral distribution data specifying a skin color;

Fig. 7 is a view for explaining a look-up table stored in a band count value storage;

25 Fig. 8 is a view for explaining a look-up table stored in a band number storage;

Fig. 9 is a block diagram showing detailed

functions of the image sensing device;

Fig. 10 is a flow chart showing the image sensing procedure of the image sensing device;

Fig. 11 is a block diagram showing detailed  
5 functions of the image processing apparatus;

Fig. 12 is a flow chart showing the process procedure of the image processing apparatus;

Fig. 13 is a view showing the relationship between multi spectral distribution data and frame band  
10 information;

Fig. 14 is a graph for explaining the process of compressing band information;

Fig. 15 is a graph showing the spectral characteristic data of RGB; and

15 Fig. 16 is a graph showing a color matching function in the XYZ colorimetric system.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An image processing apparatus of an embodiment  
20 according to the present invention will be described in detail below with reference to the accompanying drawings.

[Arrangement]

Fig. 3 is a block diagram showing the  
25 arrangements of an image sensing device 101 for sensing an image of an object and an image processing apparatus 104.



The image sensing device 101 comprises a color data sensing unit 102 for acquiring the color data of each pixel of an input image, and a multi-spectrum camera sensing unit 103 for acquiring that spectral distribution data of each pixel of the input image, which is defined by the acquired color data. Note that the color data sensing unit 102 can also be a color data sensing device connected to the multi-spectrum camera.

10        Note also that the multi-spectrum camera sensing unit 103 can be a multi-spectrum image sensing device as follows. That is, filters for acquiring band spectral distribution data differing in wavelength are used in image sensing by the above multi-spectrum  
15        camera, such that all of these filters are used to cover the total wavelength region, thereby always acquiring the spectral distribution data of all pixels. When this data is stored from the image sensing device 101 into a data storage unit 105, that spectral  
20        distribution data of each pixel of the input image, which is defined by the acquired color data is stored, and the subsequent image processing is performed.

         Furthermore, as will be described in detail later, the multi-spectrum camera can also include dedicated  
25        filters for previously defined specific colors. If it is determined that a previously defined specific color exists in acquired color data, a dedicated filter for

the specific color found is used to additionally sense all pixels. The multi-spectrum camera sensing unit 103 can also be a multi-spectrum image sensing device like this.

5           The arrangement of the multi-spectrum camera sensing unit 103 can also be a multi-spectrum image sensing device as follows. That is, of filters of the multi-spectrum camera, all previously defined filters are used to always acquire the spectral distribution  
10 data of all pixels. When this data is stored from the image sensing device 101 into the data storage unit 105, that spectral distribution data of each pixel of the input image, which is defined by the acquired color data is stored, and the subsequent image processing is  
15 performed.

          The output image signal data (the color data and the spectral distribution data defined by this color data) from the image sensing device 101 is stored in the data storage unit 105 of the image processing  
20 apparatus 104.

          A color data look-up unit 107 stores information for forming main component spectral distribution data required by a main component spectral distribution data generator 108 to estimate multi spectral distribution  
25 data by referring to the acquired color data and the spectral distribution data.

          A multi spectral distribution data estimator 109

estimates the multi spectral distribution data of each pixel from the generated main component spectral distribution data and/or the spectral distribution data defined by the acquired color data.

5           The color data look-up unit 107, the main component spectral distribution data generator 108, and the multi spectral distribution data estimator 109 construct a multi spectral distribution data estimation processor 106.

10           A color converter 110 converts the color of the multi spectral distribution data of each desired pixel by using the estimated multi spectral distribution data. A color data converter 111 converts the color-converted, multi spectral distribution data of each pixel into  
15   color data used in an output device 112.

          This output device 112 outputs an image by using the output color data from the image processing apparatus 104.

[Multi spectral Distribution Data Estimation Method]

20           This embodiment notes that pieces of band information necessary to estimate spectral distribution data and the number of these pieces of band information are specified for a certain arbitrary color. That is, the multi-spectrum camera senses spectral distribution  
25   data in accordance with a color specified by color data in an input image. Spectral distribution data is estimated by pieces of arbitrary band information

specified by the color data value of the sensed  
spectral distribution data and the number of these  
pieces of arbitrary band information. In this  
estimation, pieces of band information and the number  
5 of these pieces of band information are varied in  
accordance with the color data value.

Also, filters of the multi-spectrum camera are  
prepared for all bands necessary to estimate multi  
spectral distribution data for all color data. For  
10 example, Fig. 4 is a view showing the result of  
acquisition of eight pieces of band information when a  
bluish color is sensed by the multi-spectrum camera.  
As shown in Fig. 4, if the spectral distribution of  
input light is offset to a specific wavelength region,  
15 the multi spectral distribution data is estimated by  
interpolating four or five pieces of band information  
of the acquired band information, and the remaining  
four or three pieces of band information are redundant.

In this embodiment, the above offset of the  
20 spectral distribution is taken into consideration.  
Therefore, if input light is a bluish color, as shown  
in Fig. 5, only three pieces of band information are  
acquired, and the multi spectral distribution data of  
the input light is estimated by interpolation.  
25 Consequently, as shown in Figs. 4 and 5, it is possible  
to obtain substantially the same estimation result and  
reduce the number of band information.

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A method of estimating the multi spectral  
distribution data from band information other than the  
above interpolation method is also available. As  
described in, e.g., "New Version of Color Science  
5 Handbook 2nd ed.", page 1196, Fig. 28.29(a), band  
information required to estimate the multi spectral  
distribution data specifying a skin color need only be  
first to third spectral distribution data shown in  
Fig. 6.

10 If color data acquired from an image to be sensed  
is color data representing a skin color, filters  
corresponding to those three pieces of band information  
shown in Fig. 6, which are designated by the color data  
are selected from a plurality of filters of the  
15 multi-spectrum camera. By sensing the image by using  
each filter and acquiring these three pieces of band  
information, multi spectral distribution data  
corresponding to the color data of a skin color can be  
estimated.

20 One method of estimating multi spectral  
distribution data  $R(\lambda)$  corresponding to the color data  
of a skin color is to use a linear sum.

In this method, the above-mentioned three pieces  
of band information for the multi spectral distribution  
25 data  $R(\lambda)$  corresponding to the color data of a skin  
color are defined as first band information  $L1(\lambda)$ ,  
second band information  $L2(\lambda)$ , and third band

information  $L3(\lambda)$ , which are functions concerning the wavelength  $\lambda$ . The multi spectral distribution data  $R(\lambda)$  corresponding to the color data of a skin color can be estimated by

$$R(\lambda) = \sum_{\lambda} \{a1 \cdot L1(\lambda) + a2 \cdot L2(\lambda) + a3 \cdot L3(\lambda)\} \dots (2)$$

where  $a1$ ,  $a2$ , and  $a3$  are arbitrary coefficients which can be different from one wavelength  $\lambda$  to another

Compared to the band information different in wavelength required to estimate the multi spectral distribution data of a bluish color, the wavelength regions of band information sometimes overlap as in the case of the three pieces of band information for estimating the multi spectral distribution data corresponding to a skin color. These three pieces of band information for estimating the multi spectral distribution data corresponding to a skin color are also three main component spectral distribution data for estimating the multi spectral distribution data corresponding to a skin color.

Similar to the estimation of the multi spectral distribution data of a bluish color by the interpolation method or the linear sum method, this main component spectral distribution data can be obtained by combining arbitrary band information differing in wavelength.

Accordingly, to accurately sense a specific color

of high frequency, such as a skin color, it is better not to estimate the multi spectral distribution data from a large number of pieces of band information different in wavelength by using the interpolation method. That is, it is preferable to perform image sensing by the multi-spectrum camera by using a dedicated filter corresponding to a specific color as described above, acquire the main component spectral distribution data, and then estimate the multi spectral distribution data. In this way, it is possible to reduce the number of filters for use in image sensing and obtain good multi spectral distribution data estimation results.

In the arrangement of the multi-spectrum camera of the image sensing device 101 according to this embodiment, filter characteristics for use in multi-spectrum camera image sensing have a plurality of band characteristics different in wavelength. The camera is also equipped with dedicated filters for previously defined specific colors. By giving band information to these dedicated filters, it is possible to equally handle the filters having band characteristics different in wavelength and these dedicated filters for previously defined specific colors.

Accordingly, in the selection of filters for multi-spectrum camera image sensing by the image

sensing device 101 or in the selection of band  
information when image data is stored from the image  
sensing device 101 into the data storage unit 105,  
necessary band information are made to correspond to  
5 color data beforehand, and band information designated  
by acquired color data is selected.

[Operation of Image Sensing Device]

On the rotary filter of the multi-spectrum camera  
sensing unit 103, filters corresponding to band  
10 information necessary to estimate the multi spectral  
distribution data of color data are arranged in  
accordance with band numbers. Also, for color data  
(for a color designated by color data) sensed by the  
color data sensing unit 102, band information necessary  
15 to estimate the multi spectral distribution data are  
defined beforehand. By designating a band number, the  
defined band information can be acquired by using a  
filter corresponding to the band number.

That is, a look-up table as shown in Fig. 7  
20 defines the band numbers and the number of band  
information necessary to estimate the multi spectral  
distribution data of color data in the image sensing  
device 101.

Also, a look-up table as shown in Fig. 8 defines  
25 those filter numbers of the multi-spectrum camera  
sensing unit 103, which correspond to the band numbers  
in the image sensing device 101, and the spectral



distribution characteristics of these filters.

Fig. 9 is a block diagram showing detailed functions of the image sensing device 101. Fig. 10 is a flow chart showing the image sensing procedure of the image sensing unit 101. Note that the look-up tables shown in Figs. 7 and 8 are stored in a band count value storage 602 and a band number storage 603, respectively.

In step S801, the color data sensing unit 102 acquires the color data of each pixel to be sensed, and the acquired color data of each pixel is stored in a data storage unit 607.

In step S802, the number of band information necessary to estimate the multi spectral distribution data is acquired as a count value  $n$  from the band count value storage 602 by referring to the acquired color data, and is set in a counter unit 604. Subsequently, in step S803 a band number corresponding to a count value  $n-1$  is acquired from the band number storage 603. In step S804, the acquired band number is supplied to a filter selector 605 to select a filter corresponding to the band number. Consequently, the rotary filter rotates to set the selected filter in front of the CCD sensor of the multi-spectrum camera sensing unit 103.

In step S805, the multi-spectrum camera sensing unit 103 senses a spectrum. In step S806, the counter unit 604 decrements the count value  $n$ . In step S807, whether count value  $n > 0$  is checked, and the

processing from step S803 to step S806 is repeated the same number of times as the number of the band information.

After spectrum sensing is performed the same number of times as the number of band information, the flow advances to step S808, and the band information (spectral distribution data) equal in number to the bands corresponding to the acquired color data are stored as image data in the data storage unit 607.

The process shown in the flow chart of Fig. 10 is repetitively performed for all pixels. The acquired color data and the band information equal in number to the bands corresponding to the color data are output to the image processing apparatus 104.

The image sensing device 101 can also perform the following processing. That is, in the steps after the acquisition of the color data in step S801, all filters of the multi-spectrum camera are used to acquire the spectral distribution data of all pixels. When this data is stored from the image sensing device 101 into the data storage unit 105, only that spectral distribution data of each pixel of an input image, which is defined by the acquired color data is stored. After that, image processing using the spectral distribution data of each pixel stored in the data storage unit 105 is similarly performed.

[Operation of Image Processing Apparatus]

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The processing of the image processing apparatus by which the multi spectral distribution data of each pixel is estimated from the image data acquired by the image sensing unit 101 and output to the output device 112 will be described next.

Fig. 11 is a block diagram showing detailed functions of the image processing apparatus 104. Fig. 12 is a flow chart showing the process procedure of this image processing apparatus 104. Note that of the input image data from the image sensing device 101, the color data of each pixel is stored in a color data storage 701 of the data storage unit 105, and the band information of each pixel is stored in a spectral distribution data characteristic output value storage 706 of the data storage unit 105.

Note also that look-up tables as shown in Figs. 7 and 8 are stored in a band count value storage 702 and a band number storage 703, respectively, of the color data look-up unit 107. These look-up tables can also be acquired from the band count value storage 602 and the band number storage 603 of the image sensing device 101 and stored in the color data look-up unit 107.

In step S901, the multi spectral distribution data estimation processor 106 reads out the color data of a pixel of interest from the color data storage 701. In step S902, the multi spectral distribution data estimation processor 106 refers to the color data and

acquires from the band count value storage 702 a count value n as the number of band information required to estimate the multi spectral distribution data. In step S903, the multi spectral distribution data estimation processor 106 acquires from the band number storage 703 a band number corresponding to the count value.

On the basis of the acquired band number, the multi spectral distribution data estimation processor 106 acquires the band spectral distribution data characteristic from a spectral distribution data characteristic storage 705 in step S904, and reads out the band information from the spectral distribution data characteristic output value storage 706 in step S905.

In step S906, a counter unit 704 decrements the count value n. In step S907, whether count value  $n > 0$  is checked, and the processing from step S903 to step S905 is repeated the same number of times as the number of the band information.

Although not shown in the table shown in Fig. 7, spectral distribution data configuration information or the like for designating the generation of an arbitrary number of main component spectral distribution data for estimating the multi spectral distribution data from the "band spectral distribution data characteristic and band information" with respect to the color data is defined beforehand. This spectral distribution data

configuration information includes main component  
spectral distribution data generation designation  
information, the number of main component spectral  
distribution data, band configuration information  
5 necessary to generate each main component spectral  
distribution data, coefficient information necessary to  
generate each main component spectral distribution data,  
and each main component spectral distribution data for  
estimating the multi spectral distribution data  
10 corresponding to the color data.

If in step S908 it is determined by referring to  
the color data that the generation of the main  
component spectral distribution data is not designated,  
the band spectral distribution data characteristics  
15 acquired in step S904 and the band information acquired  
in step S905 are supplied to the multi spectral  
distribution data estimator 109.

On the other hand, if in step S908 it is  
determined by referring to the color data that the  
20 generation of the main component spectral distribution  
data is designated, the band spectral distribution data  
characteristics acquired in step S904 and the band  
information acquired in step S905 are supplied to the  
main component spectral distribution data generator 108.

25 In step S909, on the basis of the "band spectral  
distribution data characteristics and band information"  
defined by the color data, the main component spectral

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distribution data generator 108 generates the  
designated main component spectral distribution data  
for estimating the multi spectral distribution data, by  
referring to the number of main component spectral  
5 distribution data, band configuration information  
necessary to generate each main component spectral  
distribution data, and coefficient information  
necessary to generate each main component spectral  
distribution data. Note that the main component  
10 spectral distribution data can be obtained by, e.g.,  
interpolating the band spectral distribution data  
characteristics configuring the selected main component  
spectral distribution data defined by the color data.

By using the "band spectral distribution data  
15 characteristics and band information" equal in number  
to the band information acquired in steps S904 and S905,  
or by using the spectral distribution data for  
estimating the multi spectral distribution data  
corresponding to the color data including the main  
20 component spectral distribution data generated in step  
S909, in step S910 the multi spectral distribution data  
estimator 109 estimates the multi spectral distribution  
data of a pixel of interest on the basis of the  
spectral distribution data for estimating the multi  
25 spectral distribution data corresponding to the color  
data including the generated main component spectral  
distribution data, or on the basis of the "band

spectral distribution data characteristics and band information". In step S911, the estimated multi spectral distribution data is stored in the multi spectral distribution data storage 709. Note that the multi spectral distribution data can be estimated by using each main component spectral distribution data and/or the linear sum method using the band spectral distribution data characteristics and band information.

The processing indicated by the flow chart in Fig. 12 is repeatedly performed for all pixels to calculate the multi spectral distribution data of each pixel of the input image. This multi spectral distribution data is stored in a multi spectral distribution data storage 709.

By using that multi spectral distribution data of each pixel of the input image, which is estimated by the above processing, the image processing apparatus 104 causes the color converter 110 to perform color conversion for the multi spectral distribution data to obtain a desired output result, thereby obtaining the converted multi spectral distribution data. In addition, the color data converter 111 integrates the multi spectral distribution data converted by the color converter 110, by a convolution operation using a color matching function of an appropriately selected colorimetric system, thereby converting into color vector data having three values. As this color vector

data having three values, color space data unique to a device such as the  $L^*a^*b^*$  colorimetric system or the XYZ colorimetric system is generally selected. Fig. 16 shows a color matching function in the XYZ colorimetric system, as an example of a color matching function.

The obtained color vector data having three values is transmitted from the image processing apparatus 104 to the output device 112. The output device 112 converts the color vector data having three values into output signal data, which is optimum in an observation environment, of this output device 112.

Examples of the output device 112 are a display using an RGB signal values, a printer using CMYK signal values, and a display and printer using multicolor signal values other than RGB and CMYK. This output device has a function, such as a color management system (CMS), for obtaining an appropriate output, by taking account of the output characteristics of the output device, with respect to the three-valued color data. Therefore, the color data converter 111 uses this CMS to generate an output signal appropriate for the output device 112.

By the above processing, it is possible to set the bands and the number of the bands, corresponding to a color specified by the color data of an input image, of spectral distribution data to be sensed by the multi-spectrum camera, and to estimate the spectral



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distribution data from this band information. In  
addition, the spectral distribution data is estimated  
by changing the band information and the number of the  
band information in accordance with the color data  
5 value, thereby realizing image signal processing using  
multi spectral distribution data.

[Compression Process]

When the color data and the band information are  
transmitted from the image sensing device 101 to the  
10 image processing apparatus 104, if a data compressor  
for compressing the band information is used to  
compress the data amount of the band information (image  
data) as small as possible and transfer the compressed  
data, the time of the data transfer can be shortened.  
15 A data expander for expanding the compressed band  
information is of course prepared in the image  
processing apparatus 104 to restore the compressed band  
information and store the restored band information in  
the data storage unit 105.

20 The process of compressing image data having  
multi spectral distribution data or compressing band  
information will be explained below.

Fig. 13 is a view showing the relationship  
between multi spectral distribution data and frame band  
25 information. To acquire the band information of each  
pixel, one frame band information is acquired for one  
wavelength.

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Noting the band information of a pixel of interest in each frame, differences between adjacent pieces of frame band information are obtained, and correlations (Fig. 14) between these pieces of frame band information are extracted. Next, differences between pixels are obtained in the band information of one frame, and correlations between these pixels in the one-frame band information are extracted. On the basis of the correlations between the pieces of frame band information and the correlations between the pixels in the one-frame band information, optimum encoding is performed. Consequently, spectral distribution data can be efficiently compressed.

Compared to the compression of the spectral distribution data described above, the compression of the spectral distribution data characteristics does not always require frame band information but need only use data of each wavelength. Therefore, differences between data of different wavelengths of the spectral distribution data characteristics are obtained and properly encoded. In this manner, the spectral distribution data characteristics can be efficiently compressed.

In this embodiment as described above, the multi spectral distribution data can be obtained by acquiring the spectral distribution band information by using a filter which is designated by the acquired color data

of each pixel and has an arbitrary number of spectral distribution characteristics, without using all filters mounted on the multi-spectrum camera. Accordingly, it is possible to minimize the output data amount from the multi-spectrum camera and the load (time) of image sensing.

In addition, in the image processing which outputs image data constructed by an input color data value and spectral distribution data, the configuration of the spectral distribution data is defined in accordance with the color data value. This makes it possible to estimate the spectral distribution data of an object by using a minimum spectral distribution band information configuration. Therefore, the processing load (processing time) of the image processing can be reduced.

Furthermore, in image data constructed by an input color data value and spectral distribution data, the configuration of the spectral distribution data is defined in accordance with the color data value. Therefore, the spectral distribution data can be estimated by using minimum spectral distribution band information corresponding to the color data. This makes it possible to reduce the processing load (processing time) of the estimation and provide an image processing apparatus which accurately reproduces the color of object.

## Modifications

The spectral distribution data as output band information from the multi-spectrum camera includes output values of a plurality of wavelength data output values. In this embodiment, of an arbitrary number of wavelength data in the spectral distribution data, the spectral characteristic data of color data need only be obtained for at least three wavelength data. For example, three wavelength data of a plurality of arbitrary wavelength data in the spectral distribution data can be RGB spectral characteristic data shown in Fig. 15. Instead of this RGB spectral characteristic data, a data configuration directly having RGB values as color data can also be used.

In the above embodiment, the acquisition of color data by a discrete sensor is explained as an example. However, it is also possible to obtain an output value having the spectral characteristic data of color data by the multi-spectrum camera, calculate the color data from the obtained output value, and perform the above processing for this calculated color data.

This embodiment is not restricted to the use of the multi-spectrum camera using the rotary filter but can also be a multi-spectrum camera comprising an area sensor in which filters sensitive to a plurality of wavelengths are arranged. Furthermore, the embodiment can also be a multi-spectrum camera which switches a

plurality of light sources each for emitting light  
having a specific wavelength and which comprises a line  
sensor in which filters sensitive to a plurality of  
wavelengths are switched. That is, the embodiment need  
5 only be a multi-spectrum camera capable of acquiring  
band information having predetermined spectral  
distribution data characteristics, regardless of the  
optical arrangement of the camera.

As many apparently widely different embodiments  
10 of the present invention can be made without departing  
from the spirit and scope thereof, it is to be  
understood that the invention is not limited to the  
specific embodiments thereof except as defined in the  
appended claims.